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RESEARCH PAPER

Integrated nutrient management in rice-wheat cropping system

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Abstract : A study was carried out to find out the integrated dose of nutrient for rice and wheat under rice-wheat cropping system at Mainpuri and Saini, Kaushambi. The summarized results of these two interrupted sites indicate that the rice responded to the application of 25 kg ha^{-1} of zinc sulphate, which registered an additional yield of 4.90 q/ha while in wheat response of zinc sulphate was 1.75 q ha^{-1}. The use of 30 kg P_2O_5 and 60 kg P_2O_5 ha^{-1} did not influence the yield of rice and wheat in the system, during two experimental years at both sites. Application of 120 kg N + 30 kg P_2O_5 + 40 kg K_2O + 25 kg $ZnSO_4$ ha^{-1} to rice and 120 kg N + 30 kg P_2O_5 + 40 kg K_2O + 25 kg $ZnSO_4$ ha^{-1} to wheat gave higher total yield of 84.35 q ha^{-1} and saved 60 kg P_2O_5 ha^{-1} from rice and wheat doses of P_2O_5. The total production in rice and wheat obtained from the best combination of nutrients by 84.35q ha^{-1} was higher than the average productivity of India (46.56 q ha^{-1}) and U.P. (42.90 q ha^{-1}) recorded, during 2004-05. Therefore, with the integration of different nutrients in rice-wheat cropping system, the production can be sustained.

Key Words : Integrated nutrient management, Rice-wheat system, System production, Interrupted site, Synergistic effect

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INTRODUCTION

Rice and wheat are the major cereal crops as a good source of human food. Rice-wheat system is a highly adaptable grown under a wide range of various soil and climatic conditions. At present rice-wheat is main cropping pattern of the state of U.P. In the state, out of 90.00 lakh hectare area of wheat crop 47.00 per cent of wheat is sown after paddy crop that means 42.30 lakh hectare of wheat area covered after taking paddy crop. In this way, wheat and rice crops system covers an area of 132.30 lakh hectare, which is about 52.00 per cent of the gross cropped area of the state. Rice-wheat system provide high and assured returns and has made significant impact on the socio-economic status of the U.P. farmers but its continuously adoption, this system has also created numerous soil, water and imbalances in nutrients. With these problems, rice-wheat rotation has interrupted and farmers adopted new rotations. For sustainability in production, through rice-wheat, the present study was undertaken in interrupted areas.

MATERIALS AND METHODS

A Field trial was conducted for two consecutive years, during the rainy and winter seasons at Zonal Agricultural Research Stations, Mainpuri and Saini, Kaushambi, situated in South-West-Semi-Arid Zone and Central Plain Zone of U.P, respectively. The soil of Mainpuri was sandy loam having pH 8.6, organic carbon 0.45 per cent, total nitrogen 0.04 per cent available P 10 kg ha^{-1} and available K 269 kg ha^{-1} while soil of Saini was loam having pH 7.7, organic carbon 0.37 per cent, total nitrogen 0.03 per cent, available P 9.9 kg ha^{-1} and available K 90 kg ha^{-1}, therefore, the fertility status of both experimental sites was low. Rice and wheat crops were grown with six integrated doses of nutrients ($N_{120}+P_{60}+K_{40}$, $N_{120}+P_{60}+K_{40}+ZnSO_4$ 12.5, $N_{120}+P_{60}+K_{40}+ZnSO_4$ 25, $N_{120}+P_{30}+K_{40}$, $N_{120}+P_{30}+K_{40}+ZnSO_4$ 12.5 and $N_{120}+P_{30}+K_{40}+ZnSO_4$ 25 kg ha^{-1}) replicated thrice in split plot design. Half dose of N and full

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doses of P_2O_5, K_2O and $ZnSO_4$ were given at planting to both rice and wheat crops. The remaining half dose of N was top dressed in two equal doses at tillering and ear emergence stages of both crops. Irrigation was given to both crops as and when required. The paddy cv. SAKET-4 and wheat cv. K 8804 were planted in rows 30 cm apart. Paddy transplanted in second week of July harvested after 90 days in second week of October at both the stations. After paddy, wheat was sown in last week of November and harvested after 128 days in first week of April, during both experimental years at both sites. Well sun dried both crops were threshed and winnowed and finally weighed after 15-20 days of harvesting.

RESULTS AND DISCUSSION

The results of the present study alongwith relevant discussion have been presented as under:

Effect of integrated nutrient management on rice:

The same trend in grain yield of rice was found at both experimental sites. Application of $ZnSO_4$ 25 kg ha^{-1} in conjunction with $N_{120}+P_{60}+K_{40}$ kg ha^{-1} increased the grain yield (44.96 q ha^{-1}) over alone dose of $N_{120}+P_{60}+K_{40}$ kg ha^{-1} (40.07 q ha^{-1}). Combined application of $N_{120}+P_{60}+K_{40}+ZnSO_4$ 25 kg ha^{-1} increased the grain yield by 12.20 per cent over $N_{120}+P_{60}+K_{40}$ ha^{-1}. Similarly, application of $ZnSO_4$ @ 25 kg with $N_{120}+P_{30}+K_{40}$ kg ha^{-1} also increased the grain yield (43.25 q ha^{-1}) of rice by 12.90 per cent as compared to $N_{120}+P_{30}+K_{40}$ kg ha^{-1} (38.31 q ha^{-1}). The integrated dose of $N_{120}+P_{60}+K_{40}$ + $ZnSO_4$ 25 Kg ha^{-1} yield higher grains of rice (44.96 q ha^{-1}) but this yield was statistically at per with combined dose of $N_{120}+P_{30}+K_{40}+ZnSO_4$ $_{25}$ kg ha^{-1} (43.25 q ha^{-1}, Table 1). The synergistic effect of zinc with other nutrients resuled improvement in the availability of nutrients to the rice plants, which pushed up the grain yield of rice. Similar synergism of zinc application with inorganic fertilizers in rice yield was reported by Vyas *et al*. (1990), Gangaiah and Prasad (1999) and Singh *et al*. (2002). Application of $ZnSO_4$ @ 25 kg ha^{-1} increased the grain yield of rice over $ZnSO_4$ @ 12.5 kg ha^{-1} by a margin of 2.05 q ha^{-1} or 4.87 per cent. These results are in accordance with those of Kumar and Singh (1996). The integration of P_2O_5 @ 60 kg ha^{-1} improved the yield of rice by only 1.65 q ha^{-1} or 4.00 per cent compared with 30 kg P_2O_5 ha^{-1} in rice-wheat cropping system.

Effect of integrated nutrient management on wheat after rice:

Results of Table 2A and 2B display that the similar trend in grain yield of wheat was noted at Mainpuri and Saini. Integration of $ZnSO_4$ @ 25 kg ha^{-1}, with $N_{120}+P_{60}+K_{40}$ kg ha^{-1} increased the wheat yield (38.66q ha^{-1}) as compared to recommended dose of $N_{120}+P_{60}+K_{40}$ kg ha^{-1} (36.83 q ha-^{1}). Application of $N_{120}+P_{60}+K_{40}+ZnSO_4$ $_{25}$ kg ha^{-1} gave almost equal yield (38.66 q ha-^{1}) to the integrated dose of $N_{120}+P_{30}+K_{40}+ZnSO_4$ 25 kg ha^{-1} (37.46 q ha^{-1}). Therefore, the P_2O_5 doses (100% and 50% of recommended dose) did not show any response on the grain yield of wheat under rice-wheat cropping system. This might be due to higher P rates and its repeated application in every crop season, resulted in higher P build up in soil. The applied phosphorus did not loss from soil and left residual effect. This slow mobility of applied P and marked fixation, resulted in, similar yield recoveries in grain. The response of $ZnSO_4$ in wheat was 1.77 q ha^{-1} or 5 per cent. The increase in yield due to $ZnSO_4$ application in soil could be possible due to enhanced synthesis of carbohydrates and protein. Agrawal and Bhan (1997) also reported favourable direct and residual effect of zinc on wheat yield.

Effect of $ZnSO_4$ on P_2O_5 in rice-wheat cropping system:

The data available in Table 1, 2A, 2B and 2C clearly indicate that the application of $ZnSO_4$ @ 25 kg ha^{-1} in both rice and wheat with conjunction of NPK yielded almost equal yield of rice and wheat at 100 per cent and 50 per cent doses of P_2O_5. Thus, the use of $ZnSO_4$ in both crops saved 60 kg P_2O_5 ha^{-1} under rice-wheat cropping system because it increased the better utilization of P_2O_5 at lower dose through increased metabolic activities, enzymes reaction, hormones production, protein synthesis and it also acted as catalyst in various growth processes. Kunde and Puste (1997) and Singh *et al*. (2002) also reported similar favourable influence of $ZnSO_4$ application

Table 1 : Yield of rice under different doses of fertilizers (q ha^{-1})

Fertilizer doses (kg ha^{-1})	Yield (q ha^{-1})						Over all average
	Mainpuri			Saini			
	1993-94	1994-95	Pooled	1993-94	1994-95	Pooled	
$N_{120}P_{60}K_{40}$	43.54	34.12	38.83	34.40	48.25	41.32	40.07
$N_{120}P_{60}K_{40}ZnSO_4$ 12.5	47.77	37.37	42.47	36.40	49.65	42.99	42.78
$N_{120}P_{60}K_{40}ZnSO_4$ 25	49.72	39.32	44.52	39.40	51.40	45.40	44.96
$N_{120}P_{30}K_{40}$	42.90	33.47	38.18	32.14	44.77	38.45	38.31
$N_{120}P_{30}K_{40}ZnSO_4$ 12.5	47.44	37.05	42.24	34.08	46.73	40.44	41.32
$N_{120}P_{30}K_{40}ZnSO_4$ 25	49.07	39.00	44.03	37.10	47.87	42.48	43.25
S.E.±	3.99	1.61	-	0.88	0.89	-	-
C.D. (P=0.05)	NS	NS	-	1.97	2.82	-	-

NS=Non-significant

Table 2A : Yield of wheat under R/W system at Mainpuri (q ha^{-1})

Fertilizer doses in main plot of rice (kg ha^{-1})	Fertilizer dose in sub plot of wheat (kg ha^{-1})						Mean
	N_{120} P_{60} K_{40}	N_{120} P_{60} K_{40} $ZnSo_4$ 12.5	N_{120} P_{60} K_{40} $ZnSo_4$ 25	N_{120} P_{30} K_{40}	N_{120} P_{30} K_{40} $ZnSo_4$ 12.5	N_{120} P_{30} K_{40} $ZnSo_4$ 25	
			Year 1993-94				
$N_{120}P_{60}K_{40}$	39.57	37.79	35.79	35.12	31.79	32.57	35.60
$N_{120}P_{60}K_{40}ZnSO_4$ 12.5	39.57	35.79	38.01	37.12	38.01	34.68.	37.19
$N_{120}P_{60}K_{40}ZnSO_4$ 25	39.35	41.57	40.24	36.24	38.01	37.12	38.75
$N_{120}P_{30}K_{40}$	35.12	35.57	34.68	33.79	35.57	38.01	35.45
$N_{120}P_{30}K_{40}ZnSO_4$ 12.5	36.46	39.57	41.79	35.57	32.68	35.12	36.86
$N_{120}P_{30}K_{40}ZnSO_4$ 25	33.35	34.46	40.02	37.79	39.57	39.57	37.46
Mean	37.23	37.45	38.42	35.93	35.93	36.34	36.88
			Year 1994-95				
$N_{120}P_{60}K_{40}$	42.24	44.24	46.69	43.35	45.13	45.13	44.46
$N_{120}P_{60}K_{40}ZnSO_4$ 12.5	45.02	46.46	48.24	47.57	45.57	43.91	46.12
$N_{120}P_{60}K_{40}ZnSO_4$ 25	50.91	48.57	48.69	45.13	45.80	50.35	48.24
$N_{120}P_{30}K_{40}$	42.68	44.02	47.35	46.46	44.24	41.90	44.44
$N_{120}P_{30}K_{40}ZnSO_4$ 12.5	46.02	46.69	47.80	47.13	45.35	43.46	46.07
$N_{120}P_{30}K_{40}ZnSO_4$ 25	46.57	45.68	48.02	39.35	45.13	57.58	47.05
Mean	45.57	45.94	47.79	44.83	45.20	47.05	46.06
			1993-94		1994-95		
Two main plot means (average over all sub plot treatment)		S.E.±	C.D. (P=0.05)		S.E.±	C.D. (P=0.05)	
		2.03	NS		1.64	NS	

NS=Non-significant

Table 2B: Yield of wheat under R/W system at Saini (q ha^{-1})

Fertilizer doses in main plot of rice (kg ha^{-1})	Fertilizer dose in sub plot of wheat (kg ha^{-1})						Mean
	N_{120} P_{60} K_{40}	N_{120} P_{60} K_{40} $ZnSo_4$ 12.5	N_{120} P_{60} K_{40} $ZnSo_4$ 25	N_{120} P_{30} K_{40}	N_{120} P_{30} K_{40} $ZnSo_4$ 12.5	N_{120} P_{30} K_{40} $ZnSo_4$ 25	
Year 1993-94							
$N_{120}P_{60}K_{40}$	37.80	38.92	40.03	34.47	36.14	38.36	37.62
$N_{120}P_{60}K_{40}ZnSo_4$ 12.5	38.08	39.75	41.14	36.13	36.97	38.64	38.45
$N_{120}P_{60}K_{40}ZnSo_4$ 25	38.36	39.47	40.18	36.13	38.36	39.47	38.67
$N_{120}P_{30}K_{40}$	36.13	32.25	38.91	36.13	37.53	38.08	36.51
$N_{120}P_{30}K_{40}ZnSo_4$ 12.5	36.69	36.97	38.08	36.41	37.78	38.36	37.38
$N_{120}P_{30}K_{40}ZnSo_4$ 25	36.41	37.53	37.78	36.97	38.08	38.91	37.61
Mean	37.24	37.48	39.35	36.04	37.47	38.63	37.71
Year 1994-95							
$N_{120}P_{60}K_{40}$	27.80	28.10	28.30	25.60	27.20	27.80	27.46
$N_{120}P_{60}K_{40}ZnSo_4$ 12.5	28.20	29.80	29.30	26.40	28.40	27.90	28.33
$N_{120}P_{60}K_{40}ZnSo_4$ 25	28.50	30.50	31.10	27.50	29.60	28.80	29.33
$N_{120}P_{30}K_{40}$	25.00	27.10	27.60	24.60	26.50	26.40	26.20
$N_{120}P_{30}K_{40}ZnSo_4$ 12.5	26.70	28.60	28.80	26.20	27.40	27.80	27.58
$N_{120}P_{30}K_{40}ZnSo_4$ 25	27.70	28.90	29.40	27.00	28.00	28.30	28.21
Mean	27.31	28.83	29.08	26.21	27.85	27.83	27.85
			1993-94		1994-95		
Two main plot means (average over all sub plot treatment)		S.E.±	C.D. (P=0.05)		S.E.±	C.D. (P=0.05)	
		0.92	1.83		1.40	2.80	

Table 2C : Pooled yield of wheat of Mainpuri and Saini under R/W system (q ha^{-1})

Fertilizer doses in main plot of rice (kg ha^{-1})	Fertilizer dose in sub plot of wheat (kg ha^{-1})						Mean
	N_{120} P_{60} K_{40}	N_{120} P_{60} K_{40} $ZnSo_4$ 12.5	N_{120} $P_{60}K_{40}$ $ZnSo_4$ 25	N_{120} P_{30} K_{40}	N_{120} P_{30} K_{40} $ZnSo_4$ 12.5	N_{120} P_{30} K_{40} $ZnSo_4$ 25	
$N_{120}P_{60}K_{40}$	36.85	37.26	37.70	34.63	35.06	36.21	36.28
$N_{120}P_{60}K_{40}ZnSO_4$ 12.5	37.71	37.94	39.17	36.80	37.23	36.28	37.52
$N_{120}P_{60}K_{40}ZnSO_4$ 25	39.28	40.02	40.05	36.24	37.94	38.93	38.74
$N_{120}P_{30}K_{40}$	34.73	35.98	37.13	35.24	35.95	38.09	35.85
$N_{120}P_{30}K_{40}ZnSO_4$ 12.5	36.40.	37.95	39.11	36.32	35.80	36.18	36.97
$N_{120}P_{30}K_{40}ZnSO_4$ 25	36.00	36.64	38.80	35.27	37.69	41.08	37.58
Mean	36.83	37.63	38.66	35.75	36.61	37.46	37.15

Table 3 : Uptake of nitrogen, phosphorus and potassium (kg ha^{-1}) in rice-wheat system (pooled data of 1993-94 and 1994-95)

Fertilizer doses (kg ha^{-1})	At Mainpuri									At Saini								
	Rice			Wheat			Rice-wheat system			Rice			Wheat			Rice-wheat system		
	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K	N	P	K
$N_{120}P_{60}K_{40}$	50.86	11.64	51.55	127.14	21.87	102.53	178.00	33.51	154.08	54.12	12.39	54.54	76.19	13.10	61.44	130.31	25.49	115.98
$N_{120}P_{60}K_{40}$ $ZnSO_4$ 12.5	55.63	12.74	56.06	128.17	22.05	103.36	183.80	34.79	159.42	56.31	12.89	56.74	80.43	13.83	64.86	136.74	26.72	121.60
$N_{120}P_{60}K_{40}$ $ZnSO_4$ 25	58.32	13.35	58.76	133.33	22.93	107.52	191.65	36.28	166.28	59.47	13.62	59.92	81.13	13.95	65.43	140.60	27.57	125.35
$N_{120}P_{30}K_{40}$	50.01	11.45	50.39	125.07	21.51	100.86	175.08	32.96	151.25	50.36	11.54	50.72	73.42	12.58	59.87	123.78	24.12	110.59
$N_{120}P_{30}K_{40}$ $ZnSO_4$ 12.5	55.33	12.67	55.75	126.10	21.69	101.70	181.43	34.36	157.45	52.97	12.13	53.38	77.70	13.36	62.66	130.67	25.49	116.04
$N_{120}P_{30}K_{40}$ $ZnSO_4$ 25	57.67	13.20	58.11	131.26	22.58	105.86	188.93	35.78	163.97	55.64	12.77	56.07	77.64	13.35	62.61	133.28	26.12	118.68

on grain yield of rice and wheat.

Nutrient uptake:

In rice-wheat system, the maximum uptake of NPK was recorded when both crops were fertilized with N_{120}+P_{60}+K_{40}+$ZnSO_4$ $_{25}$ kg ha^{-1} at both the experimental site (Table 3). Application of N_{120}+P_{30}+K_{40} kg ha^{-1} displayed the minimum uptake of NPK in both rice and wheat crops but combination of $ZnSO_4$ @ 25 kg ha^{-1} with this dose pushed up the uptake of NPK in rice and wheat. The variation in NPK uptake of rice and wheat under rice-wheat cropping system was due to variation in yield levels. The higher production of crops in alone treatments seems to be responsible for higher NPK uptake in both individual crops and the system. Tiwana *et al.* (1999) also reported that the uptake pattern of nutrients in rice-wheat system behaves in a similar manner to yield of component crops.

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